NASA/JPL
INFLATABLE ROVER (Tumbleweed)

Future Testing and System Description

Alberto Behar, Jack Jones, Frank Carsey
Email: alberto.behar@jpl.nasa.gov
Tel: (818) 687-8627

Funding

NASA Earth Science (Code Y) & NASA Aerospace Technology (Code R)

Equipment Characteristics

Tumbleweed consists of an electronics package suspended in inflated ball; ball is 2 layers, one of nylon and one of polypropylene; total mass less is than 10 kg; 2 m diameter inflated; inflation with air takes 10 minutes; minimum wind for movement is 2 m/s; acquires and transmits GPS/environment data en route via Iridium modem, speed estimated at 5 m/s.

Goal of Future Tests

Demonstration of Tumbleweed in conditions similar to Mars mid-latitude summer. Additionally, demonstration of technology of possible scientific use in Antarctica.

Future Test Scenario

Tumbleweed is transported on flight of opportunity to unwind site, inflated, powered up, checked for communications link, and released; progress of Tumbleweed is monitored real-time anywhere in the world via web (receiving node at JPL).

Future Testing Locations

Further tests in Death Valley, Green Land, South Pole, Siple Dome, and Dome C, and have been assessed and all seem workable, other sites of opportunity can be considered.

Personnel requirements

Unit could be deployed by very few personnel (as few as one to setup, check subsystems and release)

Scientific Objective of Initial Long Range Deployment

Topography and environment measurement along route.

Test Range

200km minimum

Duration of Test

1-10 days

Scheduling of Test

Any time during an upcoming field season.

Equipment Retrieval

Not required by NASA/JPL

Tumbleweed System Description

The Tumbleweed Ball is a large, inflated ball that can be windblown and used to explore the surfaces of Mars, Venus, Titan, and perhaps Saturn's moon Io (supersonic volcanic wind) and Neptune's moon Triton (significant surface wind erosion). For Venus and Titan, the ball could also be used as a super pressure balloon that could make periodic descents to the surface be means of brief venting of helium at altitude, causing descent, and then dropping light ballast or experiments on the surface, causing ascent. Variations of PBO balloon materials studied for Venus and Titan could potentially be used for the Tumbleweed on both planets.

For each of these applications, various central payloads would be held in place by a series of lines that extend to the outside of the ball. Various versions of this basic concept have been proposed in the past in the U.S. and France, but JPL is the first to actually develop the ball and prove its feasibility experimentally and analytically. In the case of Mars, the 6-m diameter ball is easily capable of climbing over one meter rocks and up 25º hills (well over 99.9% of the Martian surface) with typical global winds that occur during the southern summer. The ball could also potentially be used as a parachute on Mars (30 m/sec descent rate) and as an airbag. Similar large balls but without the central payload have also been shown to be useful as tires for an Inflatable Rover that has been successfully tested at JPL.

Although field tests have been successfully conducted of scale models of the physical ball in the Mojave Desert and in Barrow Alaska, a long-distance test with an actual payload and satellite communications has not yet been conducted. Subsystems that have been tested individually at JPL and in Alaska include a rolling Iridium satellite communications system, rolling GPS, rolling imaging, and rolling temperature and pressure instrumentation. In fact, many of these instruments, have been successfully tested on numerous, non-rolling stratospheric balloon flights conducted jointly by JPL in Antarctica-like temperatures (-40ºC). Future Tumbleweed instruments that have already been tested in Tumbleweeds at JPL include a rolling subsurface radar that can determine ice thickness for global warming measurements, and a rolling magnetometer to measure local magnetic anomalies, such as buried meteorites on earth or tectonic plate shifting on Mars.

In the future we plan to assemble a rolling GPS system, two color cameras that look out the sides of the preferred rolling axis, temperature and pressure devices, a battery power supply, and an Iridium satellite communications system into a 3-meter diameter Spectra Tumbleweed ball. The system will be thermally verified at –40 deg C and then field-tested on the ground while rolling

over many kilometers in the California desert. The complete system will then be shipped for delivery to a location near the South Pole. The Tumbleweed will then transmit , temperature and pressure data, including two side-looking color images, every 15 minutes to JPL in Pasadena, during the approximate 4-day voyage that is required to reach the ocean hundreds of kilometers away. The Antarctic perennial winds travel generally to the coasts, and a track will be chosen, dependent on exact launch location.

This test will confirm the viability of using inflatable tires for both the Tumbleweed and the Inflatable Rover. Ultra-strong Spectra is a material that has been proposed for Mars inflatable applications, and this test will confirm its long-term durability in a cold environment. These rolling tests will also be a major boost for Tumbleweed applications at other solar system locations including Venus, Titan, Io, and Triton, and for Inflatable Rover applications on all the solid planets and moons in our solar system. This test will also enable future Earth Science Tumbleweed missions to the Arctic and Antarctic regions to measure ice thickness and temperature (global warming), ground UV intensities (ozone depletion), and possible subsurface meteorites (radar and magnetometry).